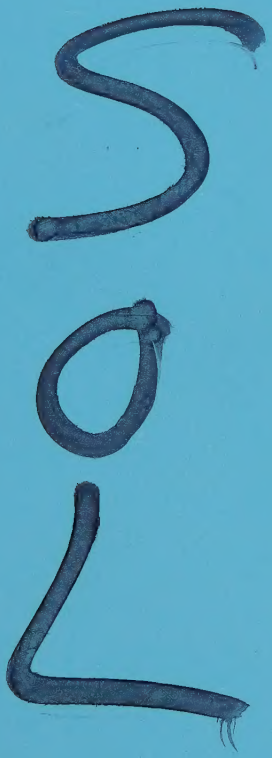
7150
DIGITAL MULTIMETER
OPERATING MANUAL

Solartron Instruments



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7150 Digital Multimeter

Part No 71500010A

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OPERATING MANUAL

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Chapter 1
General Information

INTRODUCTION

The Solartron 7150 Digital Multimeter is suitable for general-purpose bench applications and for systems use. It performs all common measurement functions and has a scale length in excess of 200000. The Multimeter has a built-in GP-IB Systems Interface port which conforms with the internationally-recognised IEEE 488 (1978) standard, thus ensuring the compatibility of 7150 with a wide range of system devices produced both by Solartron and by other manufacturers.

The front panel controls permit all main functions to be selected or changed. Additional facilities become available when 7150 is controlled remotely via the GP-IB Interface port.

SAFETY

The 7150 Multimeter has been designed in accordance with the recommendations of IEC 348. To ensure the user's safety, and the continued safe operation of the Multimeter, the user is advised to read carefully the procedures and specifications given in this Operating Manual.

Care should always be exercised whenever the input leads are being connected or removed especially where high voltages are known to exist, or high transients occur.

7150 is protected against measurement overload, up to 1.2 kV peak on voltage measurement, and 240V rms on resistance measurements.

When using 7150 on equipment which is capable of delivering high voltages (e.g. inductive circuitry giving high back-emf's) it is strongly recommended that the equipment under test is **not** switched off while 7150 is still connected. The 7150 leads should be carefully disconnected before switching off the equipment; this will help to prevent the hazards of back-emf's. The following example illustrates this. Consider the inputs connected across the secondary of a large mains transformer; the very high input impedance of 7150 is such that, in the event of the mains supply being interrupted, the resultant back emf induced in the undamped secondary could be in the order of 100kV. This is obviously hazardous to the user, and would certainly damage the 7150. User safety may be preserved by the inclusion of a switch between the 7150 and the transformer secondary; the switch could then be switched on, and off, while the transformer remained powered.

Whenever it is likely that the safety of the Multimeter has been impaired – e.g. if it shows visible signs of damage, if it fails to perform correctly, or if the specifications have been exceeded in any way – it should be made inoperative and referred to a suitable repair depot.

Any maintenance, adjustment or repair of the Multimeter must only be carried out by skilled personnel. Such adjustment, maintenance or repair should be carried out in accordance with the procedures and precautions detailed in the Maintenance Manual (Part No. 71500011A).

ACCESSORIES

Radio Frequency Probe (70457F)
High Voltage Probe (70457E)
10A Current Shunt (70457X)
Rack Mounting Kit (71501)

ASSOCIATED PUBLICATIONS

	Solartron Part No.
7150 Maintenance Manual	71500011A
Remote Control of 7150	71500013

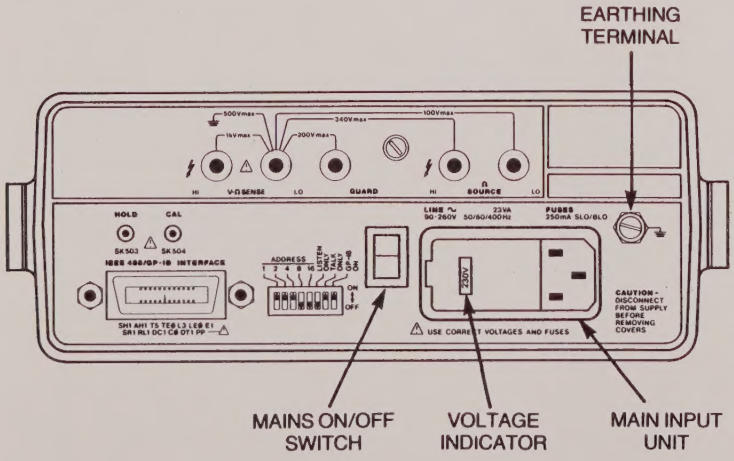
1. The 7150 is fitted with a multi-purpose mains-input unit which contains the mains input socket, fuses, voltage selector and filter. Before applying mains power ensure that the voltage selector is correctly set; '115V' or '230V' will appear in the small aperture.

   The voltage selector must be set as follows:

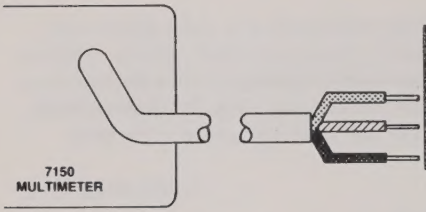
   '115V' for 95V to 130V ac input
   '230V' for 190V to 260V ac input

   To change the selector:

   Switch off 7150, using the mains switch on rear panel, remove mains plug from the input socket. Lift the hinged flap, remove the voltage-selector roller block, and refit the block such that the desired voltage, '115V' or '230V', will show through the aperture. Close flap.



2. Connect the 7150 to an ac mains outlet using the mains lead provided. The mains plug is appropriate for the country of destination. If, however, it is necessary to fit a different mains plug, this must be wired in accordance with the diagram below.



COLOUR	CONNECTION
Brown	Line (L)
Green/Yellow	Earth (E)
Blue	Neutral (N)

To protect the user in the event of a fault, it is essential that the Multimeter be connected to a protective earth system. Should an extension mains cable be used it is important that the protective earthing system is maintained.

3. If rack-mounting 7150, or to obtain the best RFI performance, connect the earthing terminal on the rear panel to a suitable earthing point (in addition to normal earthing arrangements via the power lead).

4. For rack mounting information, see Chapter 11.

Chapter 3
Front Panel Controls

The 7150 Front Panel Controls are described in the following pages.

Function selection:

V⎓ DC voltage
V∿ AC voltage
kΩ Resistance
I⎓ DC current (mA)
I∿ AC current (mA)
⏚ Diode measurement

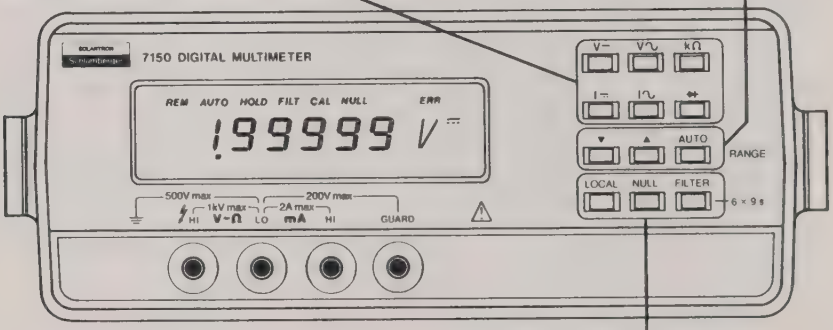
Ranging

AUTO selects, or cancels, Autoranging

▲ cancels Auto and selects next range up

▼ cancels Auto and selects next range down

▲ and ▼ may be pressed more than once for multiple range changes.



At **SWITCH-ON** the following states are automatically assumed:

Function: DC voltage
RANGE: Autorange, 1000V dc
LOCAL control
FILTER: off
NULL: off

LOCAL

Regains local control if Local Lockout is not asserted (see page 3.4)

NULL

Nulls all ranges of the input function selected (see page 3.3).

FILTER

Gives a 6½ digit scale with 'walking window' average (see page 3.4).

If the 7150 is in Remote control, only the LOCAL key is operational (providing that Local Lockout is not asserted).

NULL

The NULL facility is more than the usual front panel zero control. Its function is to cancel any small unwanted voltage, such as that produced by thermal effect on the connecting leads or terminations, which is superimposed on the input to be measured.

Null can be used with dc voltage, resistance and dc current inputs. It cannot be used with ac voltage and ac current inputs (if NULL is selected when using either of these ac inputs, the display will show 'Illegal'). The facility will null-out input values of at least:

DC Voltage	$\pm 100\mu V$
Resistance	$\pm 10\Omega$
DC Current	$\pm 1mA$

To obtain a null on DC Voltage or Resistance, disconnect the test leads from the input to be measured, then short the test leads together at the measurement source end. To null on DC Current, open circuit the input leads. Press the NULL key, and automatic nulling will then start. A null value will be measured and stored in memory for each range of the input type selected (e.g. DC Voltage). Each range is measured in turn; while it is being measured the display shows 'Null *n*', where *n* indicates the number of ranges yet to be nulled e.g. 'Null 5', 'Null 4', 'Null 3', etc. When the nulling is complete the upper NULL annunciator will be visible. If the measured null value is excessive the display will show 'Hi Null' and the request to null will be refused. See also 'Displayed Messages', page 4.3.

At power up, null always assumes the off state, and no null values are stored in memory. Pressing NULL once will switch null on. Pressing NULL again will switch null off and the null values for the input function selected will be cancelled. To re-null press NULL again, and new values will be stored. All null values are lost when the Multimeter is switched off.

Each of the input functions (e.g. DC Voltage) can be individually nulled or re-nulled. The values are stored in memory, and if the function is changed and then re-selected, the null values will still be available.

FILTER

The Filter facility provides a 6½ digit scale with a 'walking window' average. This facility gives enhanced stability, and is useful when noise is a problem. The FILTER key is a push-on, push-off switch.

When Filter is selected, repeated 5 × 9's measurements (400ms integration time) are taken. The display, which is refreshed every 400ms, shows the running average result. After the 10th reading, the result becomes the running average of the ten most recent readings. As each new reading is added, the earliest reading is discarded, hence the description 'walking window'.

To command this facility remotely, send the command I4 (6 × 9's). When in remote control, either Track (T1) or Sample (T0) can be selected. In Track, the 'walking window' average results are produced. In Sample, 7150 will make ten measurements at 5 × 9's resolution, but just one averaged result will be output after the tenth measurement has been taken.

When Filter is selected, measurements are generally given at '1 & 6 × 9's' resolution. The maximum number which can be displayed at '1 & 6 × 9's' resolution is 1999999 (ignoring decimal point). If the number exceeds this (e.g. 2154321), the display will change from 6 × 9's to 5 × 9's in order to accommodate the leading 2, and the display would show '215432'. The resolution remains at 6 × 9's if the measurement is being sent to a remote controller via the IEEE 488/GP-IB interface.

The Filter Facility is particularly useful when measuring noisy inputs or when using the more sensitive measurement ranges. Two particular uses of the Filter facility are:

1. When measuring resistance on a high ohms range (i.e. 2MΩ or 20MΩ), where pick-up on the connecting leads could cause scatter.
2. If ac mains frequency deviation is known to be abnormal (e.g. 10% deviation from 50Hz) and maximum Series Mode Rejection (SMR) is required. In these circumstances Filter will give an SMR of at least 55dB.

LOCAL

If the Multimeter is in remote control (REMote annunciator visible), pressing the LOCAL key will restore Local (i.e. front panel) control, unless Local Lockout (LLO) is asserted via the Interface. LOCAL will be inactive if LLO is asserted.

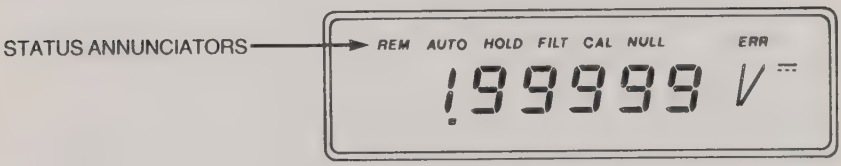
Chapter 4
The Display

The 7150 Display is described on the following pages.

The front panel display shows the following information:

- The numeric value of the result, with units (V, mA, kΩ).
- The status of the instrument, see 'Status Annunciators' below.
- Various messages, see 'Displayed Messages' page 4.3.
- Overload indication, see 'Overload' page 4.5.

The display is back-lit to enhance clarity in poor ambient light.



STATUS ANNUNCIATORS

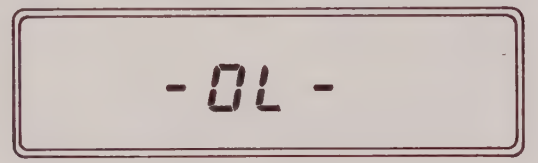
Each annunciator indicates the following:

REMote	All front panel keys except LOCAL are inactive.
AUTO range	Autoranging is selected; the Multimeter will automatically range up or down to suit the input level. Autoranging is automatically selected at switch-on, or by pressing the AUTO key at any time.
HOLD	The Hold facility is selected. This display is frozen and no further results are output. (See 'Hold Socket', page 6.3).
FILTer	The Filter facility, which provides a 6½ digit scale with a 'walking window' average, is selected.
CALibration	If flashing, the CAL shorting plug is fitted. If steady, the Calibration mode (C1) has been selected. See Cal Socket, page 6.3 and Chapter 8.
NULL	The NULL facility is active for the input function selected.
ERRor	This will appear only with CAL; it indicates a fault in the calibration circuitry. Consult a Service Department.

DISPLAYED MESSAGES

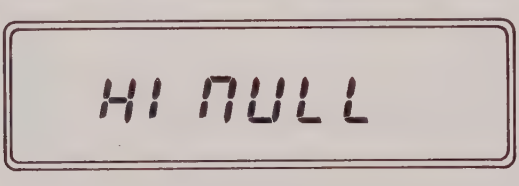
Overload

If the input present at the input terminals exceeds the full scale value for the particular function selected, the overload indication will be displayed. While the input remains at an overload level the '–OL–' legend will flash on and off.



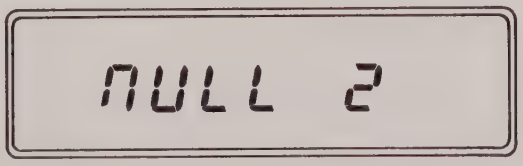
Null value too high

If a null is requested and the value to be nulled is too large (+ve or −ve) for the particular function selected, then the 'Hi Null' legend will be displayed and no null is taken.



Nulling in progress

When nulling is actually in progress the display shows 'Null *n*', where *n* is the number of ranges (of the selected function) yet to be nulled. Each range takes approximately 1.6 seconds to be nulled. If nulling Vdc for example, the display will show 'Null 5', 'Null 4', 'Null 3', 'Null 2', 'Null 1', in turn; each remaining on the display for approximately 1.6 seconds.

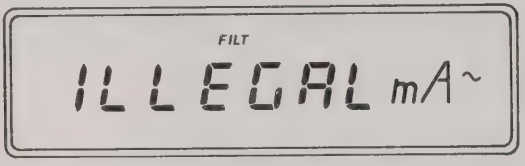


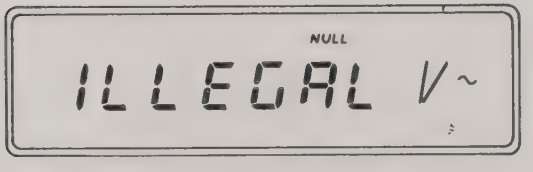
'Illegal' operating conditions

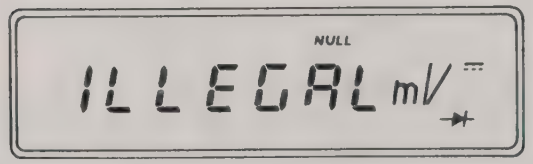
If two conflicting modes of operation are selected at the same time the 'Illegal' message will appear, together with the annunciators of the two conflicting modes – these annunciators will flash on and off. These 'illegal' operating conditions are listed below.

FILTER with Vac, Iac or diode test
NULL with Vac, Iac or diode test
CAL with diode test.

Some example 'Illegal' messages are shown below.







Function change/manual range change

Directly after an input function change, or manual range change, the displayed value will be blanked and just the lower segments of each digit will be visible. This occurs primarily for input function change, where a reading currently displayed could be confused with the new function selected.

OVERLOAD

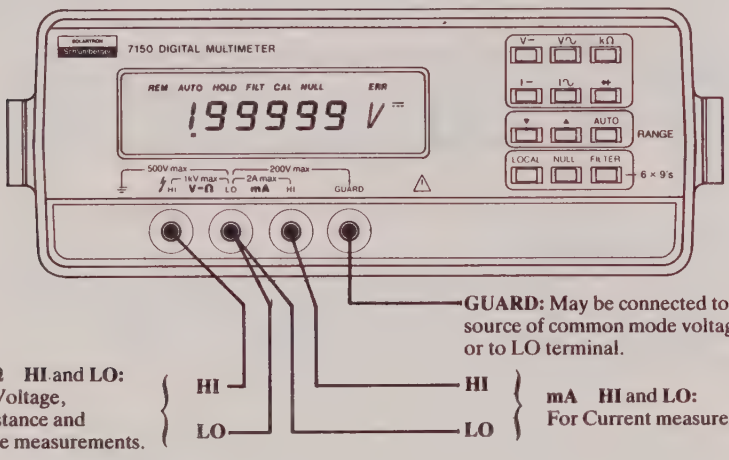
Overload occurs when the input present at the input terminals exceeds the full scale value for the particular function selected. The message '–OL–' will appear on the display in place of a measurement result if, at any time during the measurement, the input was overloaded. A flashing display, at any time, indicates that the input terminals are currently being overloaded.

If an overload occurs when the Hold facility is in use (i.e. the displayed result is 'frozen'), the Hold reading will flash, even though this value itself is not at an overload level. Overload is indicated to the controller by a '!' symbol within the output string.

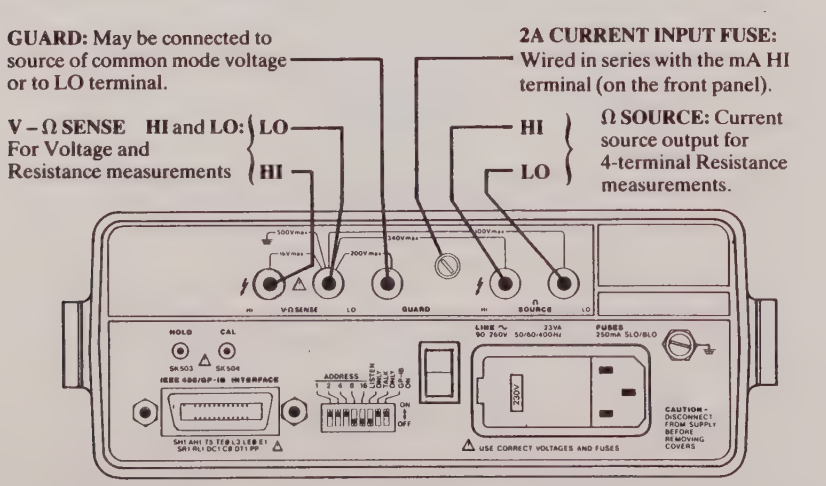
Note that any overload input, however caused, will produce an overload indication. Apart from the actual input signal itself being at an overload level, overload can be caused by two fundamental types of interference which may not, at first sight, be apparent:

1. Common mode or series mode voltages, see 'Common Mode and Series Mode Interference' on page 5.10
2. High transient voltages induced into the input source or connecting leads, even if the transients are very fast.

FRONT PANEL INPUTS



REAR PANEL INPUTS



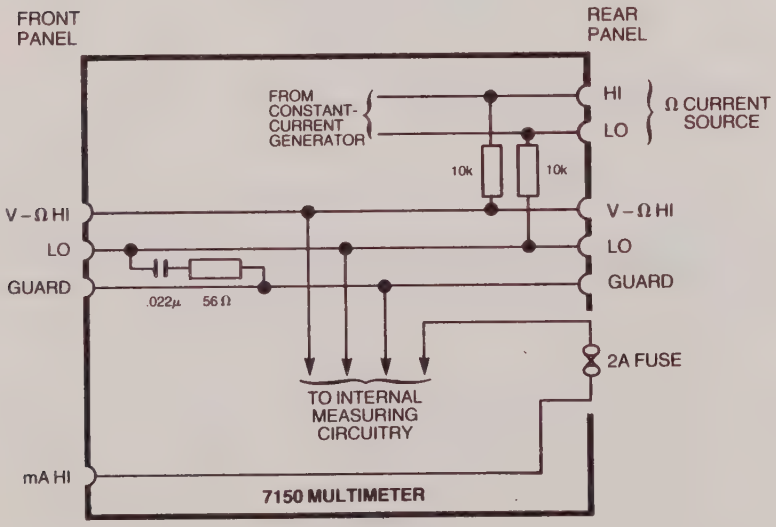
WARNINGS

1. The V – Ω HI and LO terminals and the GUARD terminal on the front panel are connected in parallel to duplicate terminals on the rear panel. Before connecting any leads to the front terminals, ensure that there are no existing connections to corresponding rear terminals. Similarly if rear terminals are to be used, ensure first that any connections to equivalent front panel terminals are removed. Duplicate connections can result in damage to the equipment, and may expose the user to high, possibly lethal, voltages.
2. Care should be always be exercised whenever the input leads are being connected or removed, especially where high voltages are known to exist, or high transients occur.
3. Do not exceed the maximum permitted voltages between terminals, as stated on the front and rear panels.
4. When the inputs are connected to equipment capable of delivering high voltages, disconnect the inputs before switching the equipment off (high back emf's which could be generated may damage the 7150). See SAFETY, page 1.1.

INPUTS

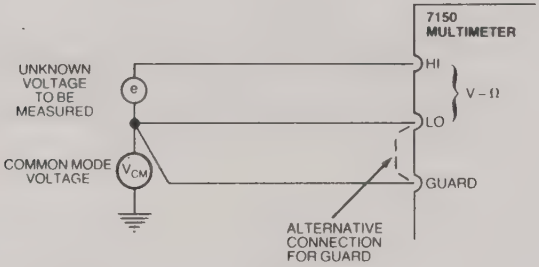
The Multimeter has 2 sets of input terminals, one set on the front panel and one set on the rear panel. The V – Ω HI, LO and GUARD terminals, which are present at both front and rear, are connected permanently through the instrument. The mA HI and (common) LO terminals, for current measurement, are on the front panel only. The Ω SOURCE (current output) terminals for 4-terminal resistance measurement are located on the rear panel.

The terminals on the front panel are intended primarily for bench use, whereas the rear panel terminals are primarily for systems use. In practice, either set of terminals may be used for either application, subject to the preceding WARNINGS. A simplified diagram of the internal wiring to the terminals is shown below.



VOLTAGE MEASUREMENT

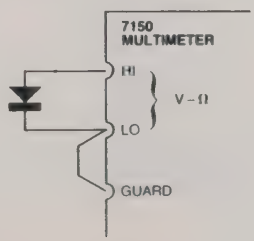
Connect the unknown voltage to the V – Ω HI and LO terminals on the front panel or to the V – Ω SENSE HI and LO terminals on the rear panel. See 'CONNECTING THE GUARD TERMINAL' (page 5.12) for GUARD connection details.



NB USE V – Ω HI, LO and GUARD on front panel
or V – Ω SENSE HI, LO and GUARD on rear panel

DIODE MEASUREMENT

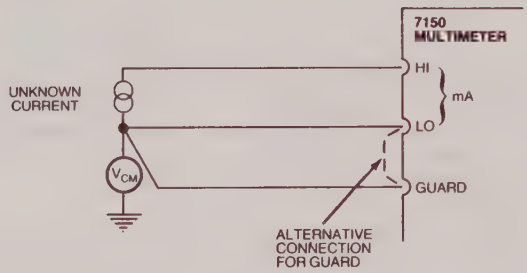
Connect the diode to the V – Ω HI and LO terminals on the front panel or to the V – Ω SENSE HI and LO terminals on the rear panel, as shown in the diagram below.



A fixed 100μA current is output at the HI and LO terminals, and the Multimeter reading shows the diode forward voltage. This is displayed on the 2V dc range with a limit of 2.4V. Forward diode voltage drops in excess of this value will cause an overload indication.

CURRENT MEASUREMENT

Connect the unknown current to the mA HI and LO terminals on the front panel. See 'CONNECTING THE GUARD TERMINAL' (page 5.12) for GUARD connection details.



The current input is protected by the 2A fuse located on the rear panel.

ALTERNATING VOLTAGE AND CURRENT

For measurement of either of the above, the performance is specified for inputs greater than 10% of range. Thus, for very small inputs, a result greater than expected may be obtained. The instrument is not faulty; the input is simply less than 10% of range.

To correct a small reading for zero error, note the reading with zero input, i.e. leads shorted if measuring voltage, or open circuit if measuring current. Now note the reading with the input applied and take the square root of the difference of the squares.

For example:
ac range = 2000 mA
zero i/p reading = 5 mA
actual i/p reading = 20 mA (i.e. 1% of range)

Corrected Reading = $\sqrt{400\text{-}25}$ = 19.4 mA

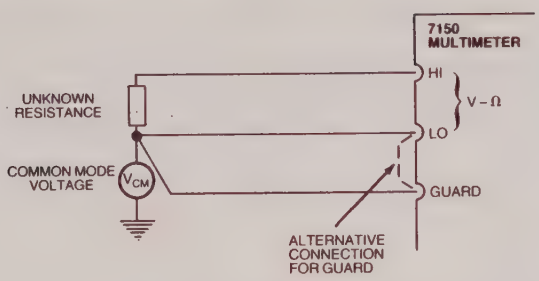
RESISTANCE MEASUREMENT

Resistance measurements may be made using the '2-terminal' or '4-terminal' method. The '2-terminal' method is suitable for measuring all resistances except very low values. The '4-terminal' method will give greater accuracy when measuring low resistances or if using resistive leads on any value resistance, but requires a 4-wire connection to the unknown resistance.

The test current for resistance measurement is provided by the internal constant-current generator which produces one of four current values according to the resistance range selected (100μA, 10μA, 1μA or 100nA). In 2-terminal measurement, this test current is output at the V – Ω HI and LO terminals, via the two internal 10k resistors (see diagram on page 5.3), whereas in 4-terminal measurement the current is derived from the Ω SOURCE terminals on the rear panel.

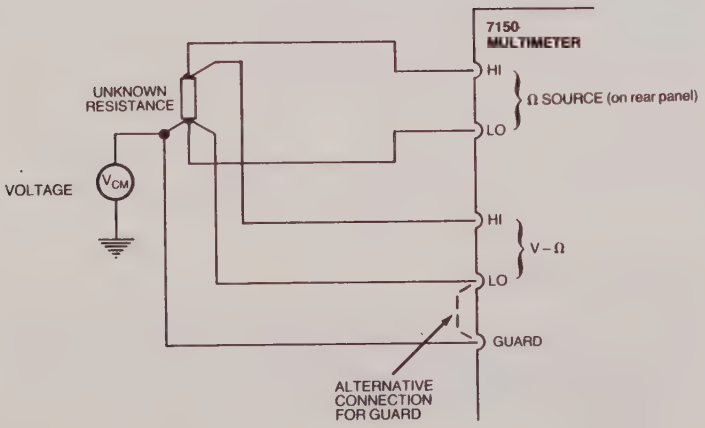
Connect the unknown resistance as shown in the appropriate diagram on the opposite page. It may be necessary to connect GUARD, either to the source of common mode voltage (this gives the best immunity to common mode interference) or to the LO terminal.

2-terminal resistance measurements



NB Use V – Ω HI, LO and GUARD on front panel
or V – Ω SENSE HI, LO and GUARD on rear panel

4-terminal resistance measurements



NB Use V – Ω HI, LO and GUARD on front panel
or V – Ω SENSE HI, LO and GUARD on rear panel
(connect these voltage sensing leads as close
as possible to the body of the unknown resistance).
Use the Ω SOURCE current outputs at rear panel.

USING THE ACCESSORIES

The following three accessories may be used with 7150:

Radio Frequency Probe (70457F)
High Voltage Probe (70457E)
10A Current Shunt (70457X)

General information for each accessory is given below; specification details will be found in Chapter 10.

Radio Frequency Probe

This is a peak-sensing rms-scaled probe which extends the frequency coverage for ac voltage measurements. Using this probe 7150 may be used to measure ac voltage at frequencies between 100kHz and 750MHz.

To use the probe with 7150:

(i) Select V dc (the probe gives a dc output).
(ii) Depending on the magnitude of the voltage being measured, select one of the following V dc ranges: 2V, 20V, 200V (the probe input can be in the range 100mV to 40V).
(iii) Connect the probe to the V–Ω HI and LO inputs.

High Voltage Probe

The probe extends measurement of dc voltage to 40kV, giving a division ratio of 1000 : 1.

To use the probe with 7150:

(i) Select V dc (the probe is for use with dc voltage only)
(ii) Depending on the magnitude of the voltage being measured, select one of the following V dc ranges: 2V, 20V, 200V.
(iii) Connect the probe to the V–Ω HI and LO inputs.

10A Current Shunt

This is a 1mΩ shunt which extends the measurement of ac or dc current up to 10A. The input current will be read as an ac or dc voltage developed across the shunt, and the voltage readings produced by 7150 must be converted by the user into a current, using the conversion of 1mV/Amp.

i.e. a 2.5mV reading indicates that the current is 2.5 Amps.

To use the shunt with 7150:

(i) Select V ac or V dc, as appropriate.
(ii) For V ac, select 2V ac range.
For V dc, select 200mV dc range.
(iii) Connect the shunt to the V–Ω HI and LO inputs.

COMMON MODE AND SERIES MODE INTERFERENCE

The 7150 Multimeter has been designed to minimise measurement error arising from interference. Nevertheless it is prudent that the user be aware of the presence of large amounts of interference. For instance, if operating near full scale on the 2V range, interference of 2V will cause 7150 to operate into a non-linear region. The Multimeter will however detect this, and in the case stated, will show the overload indication '–OL–'. The instrument will present only the correct readings, even in the presence of gross interference.

Series Mode Interference

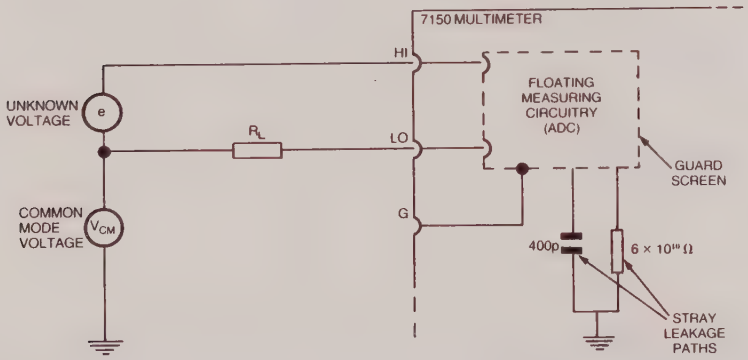
When measuring small voltages it is often possible that interference will be superimposed on the signal, and this interference may be greater than the signal itself. If the measurement is of dc, and spurious dc is also present, the voltmeter will measure both, since it is unable to distinguish between the wanted and unwanted voltages. In this case the Null facility may be used.

When measuring voltage, Null may be used to eliminate any small spurious voltage, such as that generated by a thermal emf, present in the connecting leads or terminals. When measuring resistance Null may be used to cancel out lead resistance.

Interference may equally be ac, such as pick-up from an ac mains supply. In this case the 7150 can reject a considerable amount of interference. For example, in measuring a small signal of 100μu V, mains interference (50Hz or 60Hz) of 1m V would give an error of less than 1μ V. At 4½, 5½ and 6½ digit scale lengths, the 7150 measures the input for a whole number of mains cycles, thereby giving highly effective rejection of mains-borne interference.

Common Mode Interference

It is possible that the signal to be measured will have superimposed upon it a standing voltage with respect to earth, this voltage is the common mode voltage represented by V_{CM} in the diagram below.

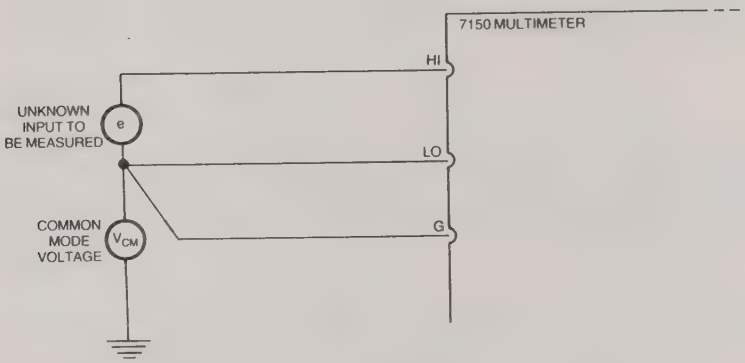


This common mode voltage, of itself, will not cause interference, as the Multimeter measuring circuits will 'float' with the voltage, up to the specified maximum. It is when the common mode produces a series mode voltage that interference will occur. This can happen if there is resistance in the Lo lead, as represented by R_L in the diagram above. Using the short test leads this should not occur, but R_L may form part of the source resistance of the sensor, in equivalent circuit terms.

V_{CM} will drive a current through the connecting leads, the return path for this current being via the inevitable stray leakage paths to earth in the Multimeter. This current will produce a voltage drop if the Lo lead is resistive, thereby producing measurement errors. Such errors can be minimised by using the GUARD facility; GUARD is connected internally to the Guard Screen which encompasses the 'floating' measurement circuitry. By connecting the GUARD terminal to the source of common mode voltage, all current produced by V_{CM} will flow in the Guard lead instead and the measurement errors will be minimised.

CONNECTING THE GUARD TERMINAL

If significant common mode interference is present, and the major portion of the input lead resistance is contained in the Lo lead, it is essential that the GUARD terminal be connected to the source of common mode as shown in the diagram below.



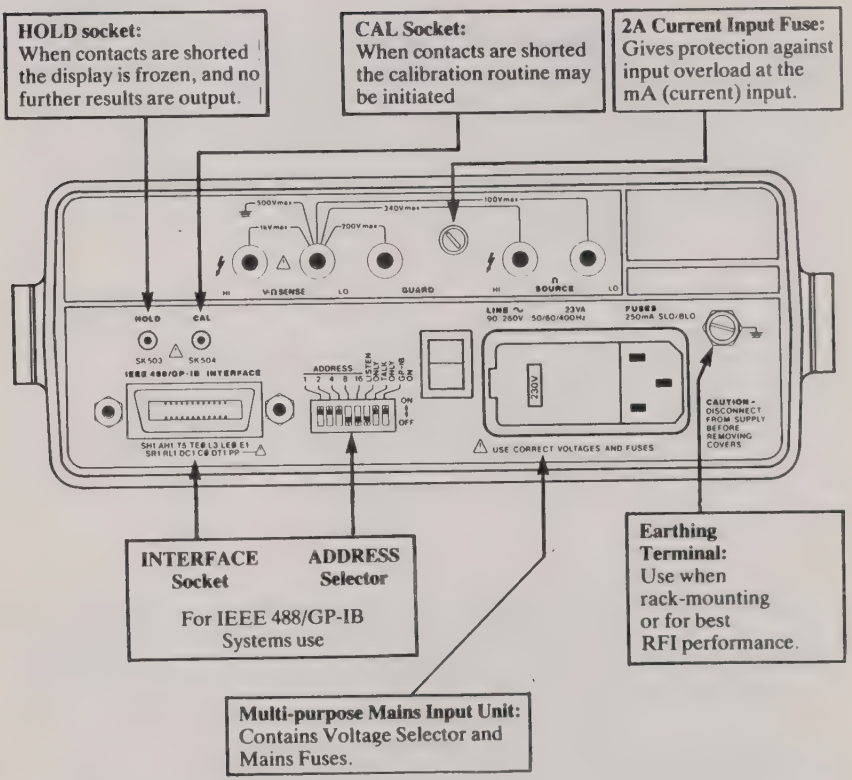
The GUARD terminal is of maximum benefit in the presence of large amounts of common mode interference. However, the GUARD is internally ac coupled to LO via a series R-C network (56Ω + 0.022μF); adequate protection for most ac interference is given via this path, and the GUARD terminal need not be connected externally.

To summarise, interference can be either series mode or common mode, and ac or dc. The table below gives the best remedial action for any combination of series or common mode, ac or dc, interference.

Interference	**Best remedial action**
dc common mode	Connect GUARD to the source of common mode, or to Lo at the source of the unknown input.
ac common mode	Connect GUARD to the source of common mode, or to Lo at the source of the unknown input.
dc series mode	Use NULL facility.
ac series mode	Rely on the series mode rejection in 7150.

Chapter 6
Rear Panel Controls and Connectors

The 7150 Rear Panel Controls and Connections are described on the following pages.



MULTI-PURPOSE MAINS-INPUT UNIT

Mains input socket: Accepts the 3-pin moulded connector on the mains lead provided.

2 Fuses: LINE and NEUTRAL are fused; both fuses must be 250mA slo-blo.
Dimensions: 20 mm × 5mm (Europe), or 1¼'' × ¼'' (USA)
(Either type can be fitted)

Voltage selector: May be set to '115V' or '230V':
'115V' for 95V to 130V ac input
'230V' for 190V to 260V ac input.

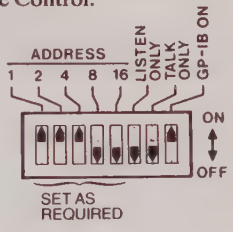
IEEE 488/GP-IB INTERFACE SOCKET

This socket is designed to accept any IEEE 488/GP-IB compatible device, such as a controller. See Chapter 7, Remote Control.

IEEE 488/GP-IB ADDRESS SELECTOR

Selects the address and status of the Multimeter, for use with an IEEE 488/GP-IB compatible device connected to the Interface socket.

The address may be set to any number between 0 and 31. As an example, for address 7, set the Selector as shown. The 'GP-IB ON' switch is shown set to ON, giving normal remote control operation; if set to OFF, the Multimeter is effectively disconnected from the Bus. See Chapter 7, Remote Control.



CAL SOCKET

The Multimeter contains an automatic calibration program in memory. This program can be accessed only by a controller connected to the Interface socket. The CALibration socket, which accepts a 2.5 mm jack plug, is provided as a safeguard against accidental operation of the Calibration program. **The program may be initiated only when a jack plug is inserted and the two terminals in the plug are shorted together.** In practice two wires may be connected to the plug and taken to a switch at a convenient location, or alternatively the terminals may be shorted inside the plug body, and the plug then inserted only when the Calibration program is to be used.

NB Never switch mains power on or off when the CAL shorting plug is fitted. See Chapter 8, Calibration.

HOLD SOCKET

The HOLD socket, which accepts a 2.5mm jack plug, permits the Hold facility to be selected locally. When Hold is selected the display is frozen, showing the last measurement taken, and no further results are sent via the GP-IB. Although no results are output, internal measurements continue to be made and the instrument remains conscious of the inputs. Thus, should an input overload occur, overload indication will be given.

To select Hold, short together the terminals inside the plug body and insert the plug in the HOLD socket. Alternatively, two wires may be connected to the plug terminals, and taken to a switch located in a convenient position. The plug could then be inserted in the HOLD socket, and Hold would be selected when the switch was closed.

EARTHING TERMINAL

If rack mounting 7150, or to obtain best RFI performance, connect the earthing terminal to a suitable earthing point (in addition to normal earthing arrangements via the power lead).

Chapter 7
Remote Control

INTRODUCTION

Full control of all 7150 facilities can be achieved via the GP-IB using a suitable controller. These facilities consist of all those offered at the front panel, plus some additional ones.

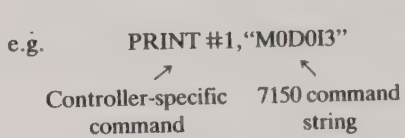
7150 will accept commands from the controller, initiate measurements, and send results back to the controller when requested. In addition, 7150 can be programmed to interrupt the controller when a measurement or an error occurs, thereby allowing the controller to conduct other tasks until interrupted, and so increase system efficiency.

Connection to the GP-IB is made using the 'IEEE 488/GP-IB INTERFACE' socket on the rear panel. The 7150 address number and Talk/Listen status is selected using the adjacent switch.

SENDING COMMANDS TO 7150

7150 is controlled by messages sent from the controller. This is normally achieved using statements of the form:

< Controller-specific command > < 7150 command string >



Controller-specific command

The 'controller-specific command' is an instruction to the controller, such as 'output', 'display', 'read' or 'print' which is expressed in the language appropriate for the controller being used. Because one of many types of controller could be used, and since each has its own language, the precise statements cannot be defined in this handbook. However, the reader is referred to a separate handbook entitled 'Remote Control of 7150' which is available from Solartron. This publication includes additional operating information and simple example programs for several commonly-used controllers.

7150 command string

The '7150 command string' is a device-dependent message which controls the 7150. The string consists of one or more commands from the 7150 Instruction Set which is tabulated on pages 7.8 and 7.9; the commands are listed in alphabetical order, and additional information is given where appropriate.

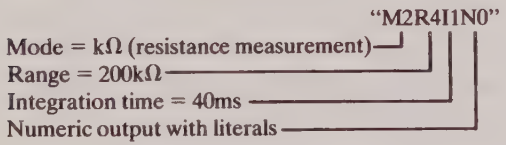
Most commands consist of a command letter and a number (the argument), e.g. I3. The letter defines a parameter (e.g. I = Integration time); the number defines the status of the parameter (e.g. 3 for Integration time = 400 ms).

Each parameter will always assume one of its settings, by virtue of, either, (1) the 'power up' condition, or (2) the commands entered using the controller.

1. **'Power up' condition** When 7150 is switched on, each parameter assumes the 'default' state as shown below:

   C0
   D0
   I3
   J0
   K0
   M0
   N0
   Q0
   R0
   T1
   U0
   Y0
   Z0

2. **Commands entered using the controller** Any or all parameters can be changed at any time using the '7150 command string'. An example command string is given below:



   All other parameters would remain as previously selected.

The commands can be entered in any order, but if both the Mode (M) and Range (R) commands are to be sent, it is recommended that the M command is always sent before the R command.

Whenever 7150 makes a measurement, this will be performed according to the parameter settings which are selected when the measurement is taken.

Certain commands, such as A (Device Clear), E (Echoback) and G (Sample), do not require an argument number.

Each command string which is sent to 7150 must end with LF (line feed), or EOI must be sent with the last character. If CRLF is sent, the CR wil be ignored.

7150 OUTPUT DATA FORMATS

Measurement results

Results are presented as ASCII strings in one of two formats depending upon the commanded status of N.

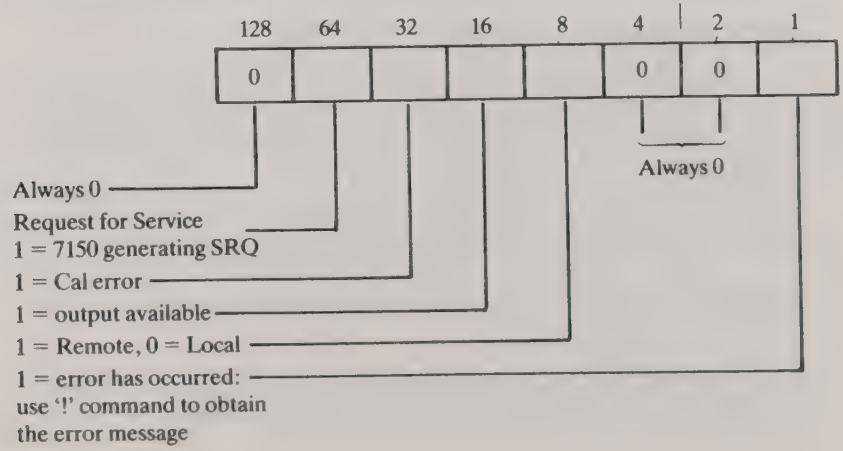
For N0, the output will be of the form
"+1.234567 _ _ V _ DC
i.e. characters 1 to 9 contain the numeric result,
character 10 is always a space,
character 11 is a space if not overload, or '!' if overload,
characters 12 to 15 indicate the measurement mode (literals),
(_ = space)

For N1, only characters 1 to 9 are presented
(i.e. overload and measurement mode do not appear).

The commanded value of U determines which of the available set of delimiter characters will be sent at the end of an output string from the 7150.

Serial Poll byte

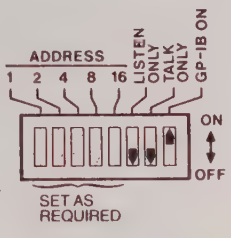
When the controller performs a Serial Poll, 7150 will output a Serial Poll byte. This byte contains 7150 status information, and takes the form:



ADDRESS AND TALK/LISTEN SELECTION

(a) For normal operation on the GP-IB (using a controller), set the selector switch on the rear panel as indicated below:

ADDRESS 1, 2, 4, 8, 16	: As required (0 to 30)
LISTEN ONLY	: OFF
TALK ONLY	: OFF
GP-IB ON	: ON



At power-up the 7150 display will show all segments and annunciators (as a display test) and then show the legend 'IEEE *n*', where *n* is the address selected at the switch.

(b) For operation without a controller, e.g. if a printer only is connected to 7150, the TALK ONLY mode should be selected. To achieve this, set TALK ONLY to ON, and set other switches as shown above.

If TALK ONLY is set to ON at power-up the 7150 display will show all segments and annunciators (as a display test), and then the message 'IEEE to'. If LISTEN ONLY had been set to ON, the message 'IEEE Lo' would appear instead.

GENERAL OPERATING HINTS

1. Using the controller, put 7150 into the Remote state. This is achieved by the controller asserting the 'REN' (remote enable) line (the controller may do this automatically), and by then addressing the 7150 as a listener (the listen address is automatically contained within the 'controller-specific message' whenever the controller outputs a command string to the 7150). Commands from the controller will not be accepted by 7150 until the Remote state has been established. (Results from 7150 may, however, be read by the controller when 7150 is in the Local state).

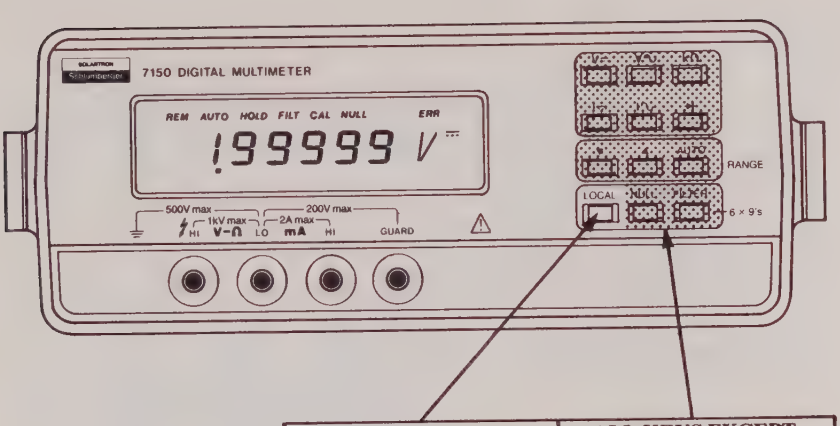
2. Send command strings to 7150, according to the measurements required. For formatting details, see the previous section 'Sending Commands to 7150' and the Instruction Set table on pages 7.8 and 7.9.

Notes: (a) Whenever a new command string is sent to 7150 before the previous string has been fully actioned by 7150, the remaining unactioned portion of the previous string will be discarded, and any unread output that the previous string may have generated will be destroyed.

(b) When the T1 Track Mode (repetitive measurements) is selected, the output buffer in 7150 will be continuously updated by each new measurement taken, whether or not any measurements are read by the controller. When the controller 'reads' 7150, the result of the last measurement taken by 7150 will be output.

3. Local control of 7150 can be obtained at any time by pressing the LOCAL key on the front panel, providing that the Local Lockout (LLO) command from the controller is not asserted. See the diagram opposite.

4. For further information, including simple example programs, refer to the associated publication, 'Remote Control of 7150' which is available from Solartron.



	LOCAL KEY	ALL KEYS EXCEPT LOCAL
REMOTE CONTROL i.e. the controller has sent the REN (remote enable) command and addressed 7150 as a listener. The REMote annunciator will be visible.	Operational, providing LLO is not asserted by the controller. Press to restore Local operation, i.e. all other keys then become operational.	Non-operational
LOCAL CONTROL i.e. the LOCAL key (or power-up) has restored the Local state.	Operational, providing LLO is not asserted by the controller, but will have no effect when already in Local control.	All operational

INSTRUCTION SET

A	–	Device clear	For use with a controller having no 'Device-Clear' command capability. Sets each parameter to the 'power-up' default state, as indicated in **bold**.
C	**0**	Normal operating mode	
	1	Calibration mode selected	Permits the automatic calibration routine to be used, see Chapter 8.
D	**0**	Display on	Normal operating state
	1	Display inhibited	Gives a higher measurement speed by removing the display updating time. When D1 is sent the message 'OFF' appears on the display, and remains visible for as long as D1 is selected
E	–	Echoback	Causes 7150 to output the present settings of all parameters (in alphabetical order) e.g. C0 D0 I3 J1 K0 M2 N1 Q0 R10 T1 U7 Y0 Z1. Use the Interrogate (?) command for individual parameters **Note:** When the Range setting is output (using either E or R?), the result will be R, followed by 2 numbers, e.g. R13; the first number gives autorange status, 0 = autorange off, 1 = autorange on; the second number gives the range selected
G	–	Sample	Produces a 'single-shot' measurement
H		Calibration High Point	For use in C1 mode only, see Chapter 8
I	**0**	6.66ms (3 × 9's)	Sets the Integration Time
	1	40.0ms (4 × 9's, 50Hz line)	For actual reading rates, see Specification, Chapter 10
	2	50.0ms (4 × 9's, 60Hz line)	
	3	400ms (5 × 9's)	
	4	10 × 400ms (6 × 9's 'walking window')	I4 cannot be used for Vac (M1) or Iac (M4) measurements
L		Calibration Low Point	For use in C1 only, see Chapter 8
J	**0**	No response to Parallel Poll	Determines the DIO line which will respond in a parallel poll. This response will only occur if 7150 is generating SRQ when the parallel poll is performed
	1	Respond on DIO line 1	
	2	Respond on DIO line 2	
	3	Respond on DIO line 3	
	4	Respond on DIO line 4	
	5	Respond on DIO line 5	
	6	Respond on DIO line 6	
	7	Respond on DIO line 7	
	8	Respond on DIO line 8	
K	**0**	LOCAL key operates as per IEEE 488	Normal operating mode when using a controller with Local Lockout
	1	LOCAL key disabled	For use with a controller having no Local Lockout capability
M	**0**	Vdc	
	1	Vac	
	2	kΩ	Selects the Mode ('Mode' is also referred to as 'Input Function' when controlled from the front panel)
	3	Idc	
	4	Iac	
	5	Diode test	

N	**0**	Numeric output with literals	Vdc, kΩ, etc. are output with results
	1	Numeric output only	Vdc, kΩ, etc. are not output
Q	**0**	SRQ on error only	7150 generates an SRQ when an error occurs (the controller may then determine the type of error)
	1	SRQ on error or output available	As Q0, except that SRQ will also be generated when an output is available. This would allow the controller to conduct other tasks while 7150 was making measurements, and the tasks would be interrupted only when each result is ready

		Vdc & Vac	*kΩ*	*Idc & Iac*	
R	**0**	Autorange	Autorange	Autorange	Selection of R1 to R6 inclusive will switch-off autoranging
	1	0.2V (Vdc only)	Not used	Not used	
	2	2V	Not used	Not used	
	3	20V	20kΩ	Not used	
	4	200V	200kΩ	Not used	
	5	2000V	2MΩ	2A	
	6	Not used	20MΩ	Not used	

T	0	Sample mode	Sample (single-shot) measurements can be made using the G command (Internal measurement triggers are disabled
	1	Track mode	Allows (normal) repetitive measurements to be taken. See 'Filter', page 3.4

U	**0**	CR, LF	Output Delimiters Selects the terminating characters to match the requirements of the particular controller
	1	ETX	
	2	CR, LF, ETX	
	3	(EOI)	
	4	CR, LF, (EOI)	
	5	ETX, (EOI)	
	6	CR, LF, ETX, (EOI)	
	7	CR	
	8	Space	
W		Write calibration constants	For use in C1 mode only, see Chapter 8
Y	**0**	Timed drift-corrects enabled	Drift corrects are always taken whenever Mode (input function), Range or Integration time are changed. Timed drift-corrects, taken automatically at 10 second intervals, will also be taken if Y0 is selected (normal operating condition). These timed drift-corrects can be inhibited by selecting Y2. One additional drift-correct will be taken with the next measurement if Y1 is selected, 7150 will then automatically revert back to Y0 or Y2 as previously selected
	1	Drift-correct with next measured result	
	2	Timed drift-corrects disabled	
Z	**0**	Disable Null	Cancels null on the Mode selected
	1	Take a new Null	New Null taken on the Mode selected
?		When preceeded by a command letter, e.g. M?, the Interrogate command will cause the present setting of that command to be output	Use this command to determine the present status of any one parameter; for example M? might produce the result M3, indicating the 7150 is currently set to Idc
!		Send error message	See Chapter 9

IEEE 488 IMPLEMENTATION

The following sub-sets of the IEEE 488/GP-IB Standard are implemented within the 7150.

SH1	Source Handshake
AH1	Acceptor Handshake
T5	Basic Talker, serial poll, talk-only selectable, unaddressed if MLA (My Listen Address)
TE0	Extended Talker no capability
L3	Listen-only selectable, unaddressed if MTA
LE0	Extended Listener no capability
SR1	Service Request
RL1	Remote/Local
DC1	Device Clear
C0	Not a Controller
DT1	Device Trigger, full capability
PP–	See below
E1	Open collector

PP– (Parallel Poll). 7150 has a parallel poll capability, but the manner in which it is configured is not covered by any of the IEEE 488 1978 Parallel Poll sub-sets. Instead, parallel poll configuring in 7150 is achieved using the device-dependent command J (see Instruction Set table, pages 7.8 and 7.9). Re-configuring is achieved using the controller itself (thereby offering an advantage over the PP2 sub-set in which reconfiguring would be achieved using switches at the instrument).

Chapter 8
Calibration

7150 can be re-calibrated, using the built-in automatic calibration program, in conjunction with an IEEE 488/GP-IB controller and accurate calibration standards. The Calibration procedure can be summarised as follows:

(i) Select the Calibration mode, i.e. send the command C1.
(ii) Select the desired mode and range to be calibrated and perform the calibration sequence. Repeat for each range/mode to be calibrated. Only one range of one mode can be calibrated at a time, and calibration is normally done range by range for the particular mode.
(iii) De-select the Calibration mode, i.e. send the command C0 to re-select Normal mode.

The 7150 address switch on the rear panel should be set as indicated below:

ADDRESS 1, 2, 4, 8, 16	: As required (0 to 30)
LISTEN ONLY	: OFF
TALK ONLY	: OFF
GP-IB ON	: ON

Equipment Required

Accurate Calibrator (for voltage, resistance or current)
Controller

1. Entering Calibration Mode

Before sending the command C0, insert a 2.5mm jack plug into the CAL socket on the 7150 rear panel; the terminals in the plug must be shorted together, either within the plug itself or using a switch to which the plug is connected. Attempts to calibrate in the absence of this shorting jack will result in an error message being issued by the 7150. The shorted jack plug must remain fitted throughout the calibration, and be removed when calibration is complete.

NB Never switch mains power on or off when the shorted jack plug is fitted in the CAL socket, otherwise the internal calibration constants may be altered.

1.1 With 7150 switched on, insert the shorted jack plug into the CAL socket on the rear panel. The CAL annunciator in the display will flash on and off, this acts as a warning that the jack plug is fitted.

1.2 Using the controller, send the command C1 to the 7150; this puts 7150 into the Calibration mode. The flashing CAL annunciator should now stop flashing, and remain permanently on to indicate that Calibration mode has been selected. The word 'CAL' should also appear on the display.

When the Calibration mode has been entered, the following conditions will apply:

(i) The following three commands cannot be used:

G (Sample)
T (Track): this assumes T0 status (≡ Hold condition)
Z (Null): this assumes Z0 status, and all nulls are deleted.

(ii) The additional commands H, L and W become available. These are for use during the calibration sequence.

2. Calibrating a measurement range

2.1 Using the controller, send the mode (M) and range (R) commands of the particular mode and range to be calibrated. This will cause the desired mode/range to be selected in the 7150.

e.g. to calibrate Vdc, 2V range, send "M0R2".

According to the mode/range to be calibrated, 7150 must be supplied with two precisely-known reference inputs (non-negative); one at approximately nominal full scale (referred to as the Hi point), and one at approximately zero (referred to as the Lo point). In the case of Vac and Iac the Lo point should be approximately 10% of nominal full scale rather than zero.

After a reference input is applied, the 7150 must be informed of the precise value of the input. This is achieved using the H command for a Hi point, and the L command for a Lo point. These commands must be accompanied by an integer argument number, of up to six digits in length, which expresses the applied input in terms of a 5 × 9's count. This may be calculated using the formula below.

H or L integer to be entered = applied input $\times 10^{(7 - R)}$

where R = commanded range number (0 to 6)

e.g. For a 2V input on the 2V range, enter 200000
For a 0.3V input on the 200V range, enter 000300

2.2 Apply the Hi point input to 7150 for the particular mode/range.

e.g. 2.00843V on 2Vdc range

2.3 Using the controller, send the H command to 7150.

e.g. H200843

The 7150 will respond by displaying 'Hi Pt' for approximately 1½ seconds, during which time it will measure the applied reference input. When finished, the 7150 will display and output its measured count, e.g. 214576. The result may differ from the applied input; this is quite normal.

2.4 Apply the Lo point input to 7150, for the particular mode/range.

e.g. 0V short circuit

2.5 Using the controller, send the L command to 7150.

e.g. L0 (leading zeroes need not be specified)

The 7150 will respond by displaying 'Lo Pt' for approximately 1½ seconds, during which time it will measure the applied reference input. When finished, the 7150 will display and output the measured count. The result may differ from the applied input; this is quite normal.

2.6 Having specified Hi point and Lo point (which may in fact be done in either order, and repeated if required), send the command W to 7150. The W command, which has no argument, causes the 7150 to compute and store the appropriate values of calibration constants for the mode/range selected. The display will show the message 'Good' on successful completion of a W command. If W is not successfully completed, an error message will be displayed and output to the controller.

2.7 Repeat instructions 2.1 to 2.6 for each mode/range to be calibrated.

3. Returning to Normal Mode

7150 must be taken out of Calibration mode, and returned to Normal operating mode (C0), otherwise the calibration data previously entered will not be accepted, and an error message will be produced.

NB The shorting jack plug must **not** be removed from the CAL socket until 7150 is returned to Normal mode.

3.1 Using the controller, send the command C0 to 7150. (7150 will then return to Normal operating mode). The CAL annunciator will flash on and off, acting as a warning that the CAL shorting plug is still fitted, see **NB** on page 8.2.

3.2 Remove the shorting plug from the CAL socket on 7150 rear panel. The flashing CAL annunciator will then become blank.

7150 is now ready for normal use.

Chapter 9
Error Messages

If an error condition occurs, 7150 will automatically generate an appropriate error message. The error message will be output to the display, and will be available at the IEEE 488/GP-IB Interface, as detailed below.

Immediately the error is detected:

(i) The display will show the error message. This will take the form 'Err.*nn*', or be an 'Illegal' or 'Hi Null' message.

(ii) SRQ (service request) will be generated via the interface. If a controller is connected to the interface, the controller may conduct a Serial Poll. 7150 will then send back a Serial Poll byte, which includes status information. The least significant bit in this byte will be '1' if an error is present, see Serial Poll Byte, page 7.4. Using the controller, the '!' command may then be sent, requesting 7150 to send the error string. This will take the form of an error number and short error message.

All the error messages are listed in the table overleaf.

Error Number	Displayed Message	Error Condition	Additional Information
0	–	No error	
1	Err.01	Bad command	Command letter was not recognised by 7150
2	Err.02	Bad argument	Argument (number) for the associated command does not exist
3	Err.03	Input buffer overflow	Input string is too long and will be ignored; re-send the commands in shorter strings
4	Hi null	Null too big	No null taken
5	Illegal: NULL & mode (flashing)	Null not allowed in this mode	Null cannot be used with Vac, Iac or diode test
6	Illegal: FILT & mode (flashing)	Filter not allowed in this mode	Filter cannot be used with Vac, Iac or diode test
7	Err.07	Cal not allowed in this mode	Cal cannot be used in diode test mode
8	Err.08	Cal inhibited	Cal command C1 has not been sent or accepted, and/or CAL plug not inserted or shorted
9	Err.09	Command not allowed in Cal mode	G, T, Z, M5 and Z1 cannot be used in Cal mode
10	Err.10	Computed Cal multiplier/ offset not OK	Cal input is out of range

Chapter 10
Specification

GENERAL

Power supply:	voltage (switch selected):	95 to 130V or 190 to 260V
	frequency:	50, 60 or 400Hz
	consumption:	< 25VA
Protection:	power supply:	fused Line and Neutral 250mA slo-blo
	current measurement:	fused 2A
	voltage measurement:	spark gap 1.2kV min

Environment

Temperature, working:	0 to 50°C
storage:	−20 to 70°C
Maximum operating humidity (non-condensing):	70% at 35°C

Otherwise to Def. Std. 66/31 Issue 01 Cat III
Safety: designed to conform to IEC 348

Dimensions:	Height:	88mm (3.46in)
	Width (including handle):	228mm (8.98in)
	Depth:	278mm (10.94in)
	Weight:	3.0kg (6.6lbs)

ACCURACY

The following apply to the Accuracy sections:

Limits of Error: expressed as ± [% reading + digits]
apply after 1 hour warm-up
ac inputs > 10% of range
dc and resistance with null in use

Calibration Temperature (T_e) is the temperature of the calibration environment. Solartron calibration occurs at 20°C and is directly traceable to the National Physical Laboratory. Re-calibration is valid at T_e from 18°C to 25°C.
Temperature Coefficient need be applied only outside the temperature span quoted with T_e.

VOLTAGE DC

SCALE LENGTH & SENSITIVITY

Nominal Range	6½ digits Sensitivity	6½ digits Full Scale GPIB*	6½ digits Full Scale Display	5½ digits Sensitivity	5½ digits Full Scale*
0.2V	100nV†	0.2350000	0.199999	1μV	0.235000
2V	1μV	2.350000	1.999999	10μV	2.35000
20V	10μV	23.50000	19.99999	100μV	23.5000
200V	100μV	235.0000	199.9999	1mV	235.000
1000V	1mV	1000.000	1000.000	10mV	1000.00

†1μV at the display.
*The full scale obtained will vary with calibration, drift correct and null.

ACCURACY Limits of Error, 5½ digit display.

Nominal Range	For 24 hrs at T_e ± 1°C	For 2 yrs at T_e ± 5°C
0.2V 2V 20V 200V 1000V	0.002 + 5	0.01 + 5

6½ digit display: add 10 digits except on 0.2V range

Temperature coefficients

Limits of error:	< 0.0015%rdg/°C
Zero (Null not in use):	< 0.2μV/°C

BUS CONTROL Commands select integration time

Scale Length	Integration Time	Tracking Speed*	Additional Error
6½	400ms	2/s	10 digits
5½	400ms	2/s	–
4½	50ms	12/s	1 digit
4½	40ms	14/s	1 digit
3½	6.67ms	25/s	1 digit

* 7150 is capable of these speeds; the rate of throughput depends on system configuration, particularly software overhead.

Settling time, sample:	< 20ms
Range of Null:	>± 100μV
Input current (0 to 50°C):	< 150pA
Input resistance:	10MΩ±1%

Overload protection

Autorange:	1.2kV peak
Commanded range: 20, 200 or 1000V:	1.2kV peak
0.2 or 2V:	500V rms

CURRENT DC

SCALE LENGTH & SENSITIVITY

Nominal Range	6½ digits Sensitivity	6½ digits Full Scale GPIB*	6½ digits Full Scale Display	5½ digits Sensitivity	5½ digits Full Scale*
2000mA	1μA	2350.000	1999.999	10μA	2350.00

*The full scale obtained will vary with calibration, drift correct and null.

ACCURACY Limits of Error, 5½ digit display, 1A.

For 24 hours at $T_e \pm 1°C$: 0.02 + 5

For 2 years at $T_e \pm 5°C$: 0.05 + 5

6½ digit display: add 10 digits.

Temperature coefficient: < 0.005% rdg/°C

BUS CONTROL Commands select integration time

Scale Length	Integration Time	Tracking Speed*	Additional Error
6½	400ms	2/s	10 digits
5½	400ms	2/s	–
4½	50ms	12/s	1 digit
4½	40ms	14/s	1 digit
3½	6.67ms	25/s	1 digit

* 7150 is capable of these speeds; the rate of throughput depends on system configuration, particularly software overhead.

Range of null: >± 1mA

Overload protection: fused 2A/250V rms

Burden at full scale: < 0.8V

VOLTAGE AC

True rms of ac component

SCALE LENGTH & SENSITIVITY 5½ digits

Nominal Range	Sensitivity	Full Scale*
2V	10μV	2.35000
20V	100μV	23.5000
200V	1mV	235.000
1000V	10mV	750.00

*The full scale obtained will vary with calibration, drift correct and null.

ACCURACY 5½ digit display.

Limits of Error for 24 hours at T_e ±1°C

Nominal Range	20Hz to 40Hz	40Hz to 10kHz	10kHz to 30kHz	30kHz to 100kHz
2V	0.25 + 70	0.1 + 70	0.1 + 200	0.3 + 700
20V				0.3 + 700
200V				0.3 + 700
1000V				0.3 + 1000

Limits of Error for 1 year at T_e ± 5°C

Nominal Range	20Hz to 40Hz	40Hz to 10kHz	10kHz to 30kHz	30kHz to 100kHz
2V	0.31 + 70	0.16 + 70	0.16 + 200	0.36 + 700
20V				0.36 + 700
200V				0.36 + 700
1000V				0.36 + 1000

Frequency range 10Hz to 20Hz: add ± 0.65% rdg
100kHz to 300kHz: add ± 9% rdg +2000
Temperature coefficient: < 0.01% rdg/°C

BUS CONTROL Commands select integration time

Scale Length	Integration Time	Tracking Speed*	Additional Error
5½	400ms	2/s	–
4½	50ms	12/s	1 digit
4½	40ms	14/s	1 digit
3½	6.67ms	25/s	1 digit

*7150 is capable of these speeds; the rate of throughput depends on system configuration, particularly software overhead.

Settling time, sample: 400ms

Overload protection

Autorange: 1.2kV peak
Commanded range: 20, 200 or 1000V: 1.2kV peak
2V: 250V rms

Maximum permitted input

Below 30kHz:	750V rms
Above 30kHz:	2×10^7V.Hz
DC content:	400V

Non-sinusoidal inputs

Peak input must not exceed 5 × full scale, or 1.2kV peak.

Additional error for 7:1 crest factor:	1%rdg
Input impedance:	1MΩ, 100pF

CURRENT AC

True rms of ac component

SCALE LENGTH & SENSITIVITY 5½ digits

Nominal Range	Sensitivity	Full Scale*
2000mA	10μA	2350.00

*The full scale obtained will vary with calibration, drift correct and null.

ACCURACY Limits of Error, 40Hz to 5kHz, 5½ digit display.

For 24 hours at $T_e \pm 1°C$:	0.1 + 100
For 2 years at $T_e \pm 5°C$:	0.2 + 100
Temperature coefficient:	<0.015%/°C

Non-sinusoidal inputs

Peak input must not exceed 5 × full scale.

Additional error for 7:1 crest factor:	1% rdg

BUS CONTROL Commands select integration time

Scale Length	Integration Time	Tracking Speed*	Additional Error
5½	400ms	2/s	–
4½	50ms	12/s	1 digit
4½	40ms	14/s	1 digit
3½	6.67ms	25/s	1 digit

*7150 is capable of these speeds; the rate of throughput depends on system configuration, particularly software overhead.

Overload protection:	fused 2A/250V rms
Burden at full scale:	< 0.8V

RESISTANCE

SCALE LENGTH & SENSITIVITY

Nominal Range	6½ digits Sensitivity	6½ digits Full Scale GPIB*	6½ digits Full Scale Display	5½ digits Sensitivity	5½ digits Full Scale*
20kΩ	10mΩ	23.50000	19.99999	100mΩ	23.5000
200kΩ	100mΩ	235.0000	199.9999	1Ω	235.000
2000kΩ	1Ω	2350.000	1999.999	10Ω	2350.00
20000kΩ	10Ω	23500.00	19999.99	100Ω	23500.0

*The full scale obtained will vary with calibration, drift correct and null.

BUS CONTROL Commands select integration time

Scale Length	Integration Time	Tracking Speed*	Additional Error
6½	400ms	2/s	10 digits
5½	400ms	2/s	–
4½	50ms	12/s	1 digit
4½	40ms	14/s	1 digit
3½	6.67ms	25/s	1 digit

*7150 is capable of these speeds; the rate of throughput depends on system configuration, particularly software overhead.

ACCURACY Limits of Error, 5½ digit display.

Nominal Range	Test Current	For 24 hrs at $T_e \pm 1°C$	For 2 yrs at $T_e \pm 5°C$
20kΩ	100μA	0.004 + 5	0.03 + 5
200kΩ	10μA	0.005 + 5	0.04 + 5
2000kΩ	1μA	0.004 + 5	0.03 + 5
20000kΩ	0.1μA	0.05 + 20	0.08 + 20

6½ digit display: add 10 digits.

Nominal Range	Temp Coeff % rdg/°C	Settling Time (sample)
20kΩ	< 0.004	20ms
200kΩ	< 0.005	20ms
2000kΩ	< 0.004	40ms
20000kΩ	< 0.01	100ms

Range of null: > ±10Ω

Overload protection: 240V rms

Open circuit voltage: <7V

INTERFACE

Built in as standard

Protocol and connection: IEEE 488 (1978)
Provides full talker/listener facilities and remote control of all 7150 functions.
Subset: SH1, AH1, T5, TE0, L3, LE0, E1, SR1, RL1, DC1, C0, DT1, and parallel poll.

INTERFERENCE REJECTION

Normal Mode, dc measurement
6½, 5½, 4½ digits, 50/60 Hz ± 0.1%: >60dB
6½ digits, 50/60 Hz ± 10%: > 55dB

Effective Common Mode with 1kΩ imbalance
DC measurement: rejection of dc: > 140dB
6½, 5½, 4½ digits, 50/60 Hz ± 0.1% > 120dB
6½ digits, 50/60 Hz ± 10%: > 100dB
AC measurement: 50/60 Hz ± 10%: > 40dB

Maximum permitted common mode: 500V dc or peak

ACCESSORIES

RADIO FREQUENCY PROBE (70457F)

Peak-sensing, the probe provides dc voltage to the multimeter, which displays the rms value. Complete with fittings and adaptors.

Limits of Error:	100kHz to 500MHz (1V rms sine wave) ±1dB
	100kHz to 750MHz (1V rms sine wave) ±3dB
Voltage Range:	100mV to 40V
DC Isolation:	200V
Working Temperature:	0 to +50°C
Lead Length:	1m

HIGH VOLTAGE PROBE (70457E)

Extends measurement of dc voltage to 40kV. Complete with fittings and adaptors.

Voltage Range:	1kV to 40kV
Division Ratio: at 20kV, 23°C	(1000 : 1) ±0.5%
Limits of Error: 1kV to 40kV, 23°C	±3%
Temperature Coefficient:	<200 ppm/°C
Working Temperature:	0 to +50°C
Lead Length:	1.8m

CURRENT SHUNT, 10A (70457X)

Extends the current measuring capacity to 10A. Simple plug-in unit.

Shunt Value:	1mV/A
Accuracy:	±0.9% fs
Range:	1 to 10A
Temperature Coefficient:	±250ppm/°C
Maximum Voltage Burden:	100mV at 10A
Absolute Max. Current:	12A

RACK MOUNTING KIT (71501)

The 7150 is a ½-rack width unit. Using the 71501 allows two 7150's to be mounted side-by-side in one 19 inch rack width.

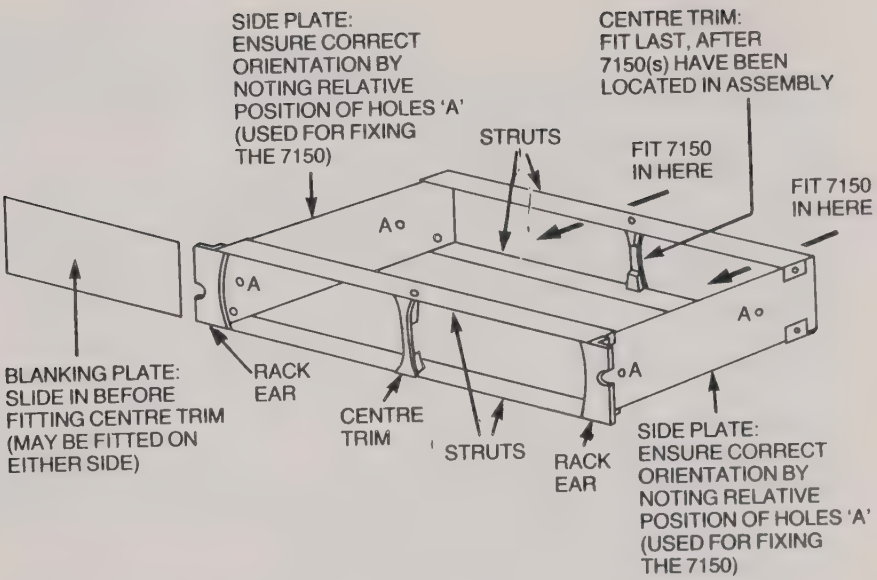
Chapter 11
Rack Mounting the 7150

The Rack Mounting Kit (71501), which is available as an optional accessory, will be required to rack mount a 7150. Each kit will allow two 7150's to be mounted side by side in a standard 19'' rack (kit height is 2U's high). If only one 7150 is to be mounted, the blanking plate (included in the kit) can be fitted. Before attempting to assemble the kit, refer to the instructions below and the diagram (overleaf) which illustrates a fully assembled kit.

1. Identify the various parts of the kit:

   4 struts
   2 side plates
   2 centre trims
   2 rack ears
   8 M4 × 8mm screws (for fitting the struts and rack ears)
   4 M3 × 10mm screws (for fitting the centre trims)
   4 M4 × 16mm screws (for fitting the 7150's)
   1 blanking plate
   8 captive nuts (four to be fitted into each 7150)

2. Fit the two rear struts to the side plates, using the M4 × 8mm screws. Ensure that the struts are fitted to the 'rear' end of the side plates, the correct orientation of the side plates is given by the relative position of the holes marked 'A' in the diagram overleaf.



3. Fit the 2 front struts and 2 rack ears to the side plates, using the (same) M4 screws.

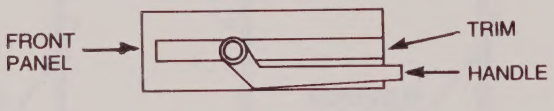
4. If only one 7150 is to be fitted, locate the blanking plate into the appropriate position (left-hand or right-hand side) by sliding the plate into the inner recess in the rack ear. Next, take a centre trim and butt it against the other edge of the blanking plate, then fix the centre trim to front struts using the M3 screws. This will lock the blanking plate in position.

5. If two 7150's are to be fitted, fit the centre trim to the front struts, using the M3 screws (do not fit the blanking plate).

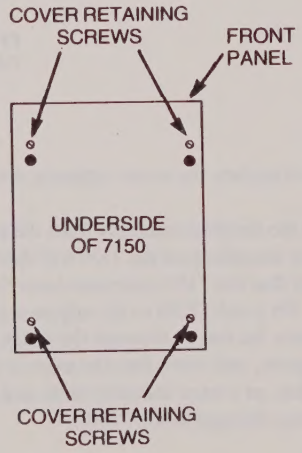
6. Prepare the 7150(s) for rack mounting as follows:

6.1 With the carrying handle in the position shown below, gently pull the handle away from the case at the pivot points and detach the handle. Note that on later models the handle can be detached only when it is pointing vertically upwards.

6.2 Peel off the trim on both sides of the 7150.

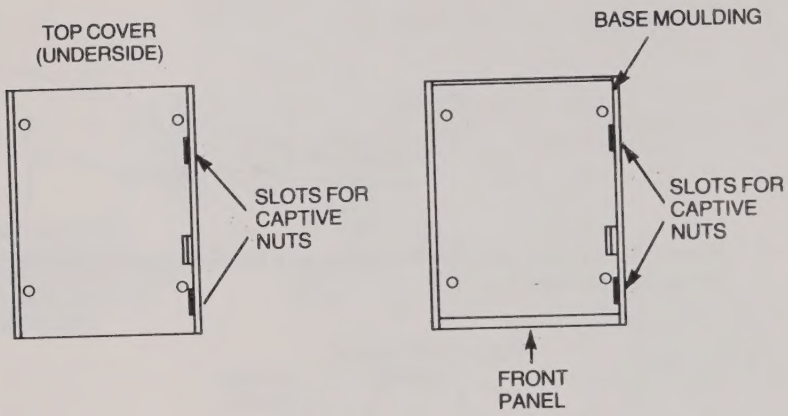


6.3 Remove the 4 rubber feet from the underside of the instrument, by carefully prizing out with a small screwdriver.



6.4 Remove the 4 cover retaining screws on underside of 7150, and carefully lift off top cover.

6.5 Fit four captive nuts in the four slots indicated in the diagram below; two in the top cover, and two in the base moulding.



6.6 Refit top cover and replace the cover retaining screws.

7. Slide (each) 7150 into the finished assembly from the rear as shown in the diagram on page 11.2. The front moulding on the 7150 will then butt against the front centre trim and rack ear, such that the 7150 protrudes from the front of the assembly by approximately 6 mm. Fix (each) 7150 to the adjacent side plate using two of the M4 × 16mm screws; pass the screws through the holes in the side plate, marked 'A' in the diagram, and screw into the captive nuts within the 7150. Use only the screws provided, or ensure that screws do not exceed 16mm in length (longer screws may cause damage to the 7150).

8. Fit the rear centre trim to the rear struts, using the M3 screws, as shown in the diagram on page 11.2.

9. Fit the complete assembly into a standard 19 inch rack. Ensure that adequate ventilation is provided.

10. See Chapter 2 'Installation' before connecting 7150 to a mains supply.

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